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AECB STAFF ANNUAL REPORT OF DARLINGTON NGS 'A' FOR THE YEAR 1990

June 1991

Canada

Report

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1. INTRODUCTION

AECB staff resident at Darlington NGS 'A' ensure that the station operation is monitored and licensing requirements are enforced. This process requires that the project staff, in co-operation with AECB staff in Ottawa, monitor reactor operations, conduct audits and inspections, witness important activities, and review station documents and reports from the licensee.

A formal Annual Review Meeting is held with the station management and senior staff in order to discuss safety-related issues and to present to Ontario Hydro an assessment of station operation during the year. This meeting is convened following the preparation, in draft form, of an AECB Staff Review of Station Operation. This is the first of such reports for Darlington NGS 'A'. The report is compiled using, amongst other information, Ontario Hydro Quarterly Reports. These are a requirement of the licence and summarize key features of station operation during the year.

This report presents the AECB staff review of major licensing issues and of the operational performance of the station during 1990. In addition to the reports mentioned above, other Ontario Hydro reports, official correspondence, and observations of AECB site staff have been taken into consideration. The report is limited to those aspects of station performance that AECB staff consider to have some safety significance. Developments of significance associated with issues addressed in the report that occurred in the early part of 1991 are also mentioned.

2. STATION OPERATION

2.1 Unit 1

Unit 1 reactor achieved first criticality on October 29, 1990. After completion of reactor physics measurements, Unit 1 reactor was allowed to have the power raised to 10% full power (FP) on November 23, 1990. The reactor was allowed to increase power to 25% FP on December 13, 1990 for a turbine load rejection test and a loss of class IV power test. The unit was synchronized to the grid for the first time on December 19, 1990. By year end, the reactor was allowed to raise power to 60% FP for a turbine load rejection test, reactor trip test and reactor regulating system setback test. The net electrical output in 1990 was 36816 MWh.

2.2 Unit 2

The total electrical power generated by Unit 2 during 1990 was 3146112 MWh gross (2777482 MWh net). The unit was declared in-service on October 9, 1990. The unit net capacity factor for 1990 since the in-service date was 64.9%.

During 1990, the unit was beset by a number of problems. At the beginning of the year, the reactor was restricted to 20% FP pending completion of the review of the shutdown system software by AECB staff. The operating

licence to allow 100% FP operation of Unit 2 was issued by the Board on February 23, 1990. In mid-March 1990, commissioning of the unit was stopped when it was found that the generator rotor had developed a substantial crack. The rotor was scrapped and replaced, after it had been suitably modified, by the one procured for Unit 4.

Commissioning resumed in June 1990 and full power in Unit 2 was reached for the first time on July 4, 1990. The unit was shut down in September 1990 for a three week outage to correct a problem in the Moisture Separator Reheaters (MSRs). The MSRs control the moisture content of the steam to the low pressure turbine generators. Additional baffle plates were installed in both reheater stages of each MSR to "detune" the high pitch whining noise (>100 decibels) which was emanating from the MSRs when the reheaters were in service.

On-power reactor refuelling was approved by AECB staff on November 1, 1990. Refuelling proceeded normally until November 30, 1990. When attempting to refuel channel N12, some fuel elements were crushed during the refuelling sequence. It has been shown recently that the fuel damage in the Unit 2 core is more widespread than originally thought (see Appendix III-6 for further details).

Following the discovery of the damaged fuel in channel N12, the reactor was shut down on January 12, 1991 and is still currently shut down.

2.3 Tritium Removal Facility

Following an 18 month outage for major repairs and modifications, the Tritium Removal Facility (TRF) was returned to service on June 11, 1990. By year end, 1440 tonnes of tritiated heavy water from Pickering NGS had been reprocessed, and 19 MCi of tritium permanently immobilized and stored in metal tritide form. The TRF capacity factor since its return to service has been 79%. The airborne tritium emissions from the TRF were well below the 1% Derived Emissions Limits (DEL) target; in fact, they ranged between 0.01 and 0.1% DEL for most of the time that the TRF was in service.

3. AECB STAFF REVIEW OF OPERATIONAL SAFETY ASPECTS

3.1 Station Compliance

The operation of a nuclear power station in Canada must comply with the Atomic Energy Control Regulations and the Physical Security Regulations; in practice these regulations are imposed on the station through an Operating Licence. The licence references several documents, including the station "Operating Policies and Principles" and "Radiation Protection Regulations". Station compliance is evaluated against licence conditions and the referenced documents.

3.1.1 Compliance with AECB Regulations

There were no apparent violations of the Atomic Energy Control Regulations at the Darlington Nuclear Generating Station during 1990.

3.1.2 Compliance with the Physical Security Regulations

A compliance inspection of the physical protection measures in effect at Darlington revealed one violation of the Physical Security Regulations. A number of security guards were being employed within the licensed facility prior to submitting the necessary documentation to the AECB for review as required by section 29 of the Regulations.

A number of other minor deficiencies were noted as a result of the compliance inspection; these items are being addressed.

3.1.3 Compliance with the Licence

The operation of reactor units 1 and 2 at Darlington NGS is governed by Power Reactor Operating Licences 13-1/90 and 13/90, respectively. The TRF is operated under a separate licence, Operating Licence No. 4/89. With the following exceptions, Ontario Hydro has complied with the conditions of these licences.

3.1.3.1 Operating Policies and Principles (Condition A.A.1)

Seven events were reported which violated the station Operating Policies and Principles. These events are described briefly in Section 3.7.

3.1.3.2 Maintenance (Condition A.A.11)

AECB site staff is not satisfied with the large and ever growing number of work packages still outstanding. The fact that almost 12,000 identified tasks involving all major work groups and the Technical Section existed at year end calls into doubt Darlington's ability to meet licence commitments to assure "reliability and effectiveness of all equipment and systems as claimed in the Safety Report". According to combined work group estimates, these tasks represent a total of approximately 38 person years of work. Although station management has acknowledged this as being a significant long term problem, no steps have been taken as yet to solve it. Section 3.9 gives specific detail on this issue according to individual work groups.

3.2 Quarterly Reports

The four Quarterly Reports for 1990, required by the licence, were produced in a timely manner by Ontario Hydro. These reports contained detailed information on the performance of station reactor units, safety systems and safety related activities, including chemical and radiation control, as well as the handling of prescribed substances. Also included are data relating to safety reliability assessments, faults, and predictions for future unavailability of safety systems. In its review, AECB staff found the reports to be clear in content and, as far as could be ascertained, accurate records of station performance and events. In future, the fourth quarterly report should contain a clear statement as to whether operation of the station was in compliance with the reactor operating licence and any exceptions should be explained.

3.3 Radiation Protection

None of the station operating personnel received a radiation exposure in excess of the regulatory limits during 1990. The accumulated whole body dose for the station was 105 mSv, of which 25.4 mSv was due to internal exposure with the remainder due to external exposure. The total neutron dose was 3.0 mSv. The Ontario Hydro station whole body dose target for 1990 was 127 mSv.

Supplementary doses were also assigned to a number of workers to cover specific organs. The maximum dose to an individual and total dose for extremities were 2.9 mSv and 19.7 mSv respectively; 1.3 mSv and 14.4 mSv were assigned as skin dose. There was no skin dose assigned due to transfer from contaminated tritium surfaces. The only lung dose assigned due to tritium gas exposure was 4.8 mSv.

During 1990, there were seven supervisor investigations into radiation incidents. It is too early in the life of the station to say whether these indicate inadequate attention to radiation control procedures.

Lastly, there was one work refusal in the TRF/Heavy Water Management Building over a small quantity of tritiated oil. The situation was resolved satisfactorily between Station Management and the concerned workers without formal AECB staff involvement. In general, AECB site staff is of the opinion that the radiation protecton at Darlington NGS is satisfactory.

3.4 Station Effluents and Environmental Monitoring

The station gaseous and waterborne emissions and environmental monitoring measurements are shown in Appendix II. There were no emissions from the station during 1990 which exceeded the 1% DEL weekly targets.

3.5 Major Process Systems

Any Type A process system faults (defined as those faults which would cause significant fuel failures in the absence of safety-system action) are to be reported promptly to the AECB. No Type A process system failures occurred during the past year. Several notable incidents of a less serious nature than a Type A fault were reported; these events are briefly mentioned below.

3.5.1 Reactor Process, Control and Fuel Handling Systems

There were 19 Significant Event Reports (SERs) relating to the Reactor Process, Control and Fuel Handling Systems of which three were reportable under conditions of the Darlington NGS 'A' operating licence. Those having safety significance are discussed below.

The first process system problem occurred with Unit 2 in the guaranteed overpoisoned shutdown state (GOSS), when a potential moderator purification flowpath through the Moderator Sampling System was discovered. There was no

actual flowpath established. The issue was resolved by revising the condition guarantee isolating the main moderator from purification to include the five (normally closed) valves through which a flowpath might have been established.

The significance of this incident is that the GOSS should provide absolute assurance that, in this state, the reactor cannot go critical.

The second notable event involving a reactor process system was a violation of Operating Policies and Principles (OP&P) 30.1(f), which states that 'the reactor shall always be maintained either critical or in a guaranteed shutdown state or in an active transition to one of these two states'. The status of Unit 2 was thought to be low power critical, when in fact, the reactor had become sub-critical. Once sub-criticality was confirmed, poison was removed from the moderator and the reactor was brought to criticality. This incident occurred on December 30 and is still under review by Ontario Hydro staff.

OP&P 30.1(f) is intended to ensure that the reactor is operated within a clearly defined envelope. The reported violation of OP&P 30.1(f) is significant for two reasons: (1) sub-critical operation is outside of the normal operating envelope, and (2) until sub-criticality was confirmed, the operators were unaware of the true condition of the reactor.

Several problems concerning reactor fuel were experienced at Darlington this year. During reactor physics commissioning tests on Unit 1, unexpected flux tilts led to the discovery that 108 (of 144) depleted bundles initially loaded into the core contained 0.5% U_{235} by weight instead of the standard 0.4%. A re-assessment of the Neutron Overpower (NOP) protection for Unit 1 undertaken by Ontario Hydro's Nuclear Safety Department concluded that the previously recommended NOP trip setpoint was still valid. Investigations into this incident revealed that the 0.5% weight U_{235} fuel bundles were manufactured in 1985 and shipped to the Bruce site without any unique identification markings, and apparently without formal notification of the Bruce site staff about the non-standard isotopic content of the fuel. Two hundred and sixteen (216) of these 402 bundles were subsequently shipped to Darlington, and in the absence of any additional information were treated as standard isotopic content depleted fuel. Records at Darlington show that thirty-six (36) of the 0.5% U_{235} content bundles were loaded into Unit 2. The asymmetrical distribution of these bundles in the core allowed the situation to remain undetected. An analysis of NOP trip setpoints carried out for Unit 2 using the correct isotopic concentrations concluded that the setpoints in use were acceptable.

As well as the safety implications noted above, this incident clearly shows a failure of the Quality Control Procedures for nuclear fuel procurement and handling. Actions have been taken by Ontario Hydro to correct this failure. AECB staff will be auditing fuel handling control in 1991.

In December, while operating at full power, problems were encountered with Unit 2 during attempts to fuel channel N12. The fuel push was unable to be completed, and when the decision was made to close up the channel, it was found that the shield plug could not be re-inserted. Attempts to install

the closure plug were only partially successful (the shield plug was left in the fuelling machine), as it could be rotated into a position where it was locked in place, but not to the fully closed, leak-tight position. The unit was shut down late in December to prepare for the installation of a maintenance cap. Although this summarizes the problem and follow-up activity to the end of 1990, it should be added that the initial fuelling mishap was subsequently discovered to be a direct result of cracked fuel bundle end-plates. The mystery surrounding end-plate damage has yet to be resolved and has resulted in extensive outages for both Units 1 and 2.

On March 22, 1991, Ontario Hydro made a formal request to the AECB for approval to restart Unit 1. The request was denied on the basis that Ontario Hydro clearly did not understand the cause or extent of the reactor core damage.

In October, during commissioning of Unit 1 fuelling machine bridge and carriage, a movement of the Unit 1 west carriage was requested, but the Unit 2 west carriage moved instead. The fault was traced to a defect in the software which had been used to compile data for all fuel handling control units. The fuel handling software has been changed to prevent a recurrence of this event.

While no hazardous consequences resulted from this incorrect motion of the carriage, a similar software error in the fuel handling control system at Bruce NGS in January 1990, caused damage to a channel end fitting and a heat transport system leak. In response to concerns regarding safe operation of the fuelling machines Ontario Hydro initiated a review by an external consultant of the control software. There were eight recommendations from this review.

3.5.2 Secondary Systems

There were twenty-one (21) SERs relating to the secondary systems; included in these are the boiler feedwater, main steam, condensate and turbine generator. One of these events was reportable under conditions of the Darlington NGS 'A' operating licence. A breakdown of these SERs is as follows:

- Thirteen events involved turbine trips and six involved activation of generator protection. These were all associated with minor problems either with equipment or the control logic which were readily fixed.

- One event involved cracks found in the main boiler feed pump suction lines. These were caused by high frequency fatigue failure due to excessive vibration. Corrective action was taken on all reactor units.

- One event involved the atmospheric steam discharge valve silencers which suffered major damage due to the installation of an incorrect internal component.

3.5.3 Electrical Systems

There were four SERs relating to electrical systems. The two of significance were the catastrophic failure of the Unit 1 main output transformer and the severe damage to many turbine blades of an emergency standby generator. The latter was reported under conditions of Darlington NGS 'A' Operating Licence.

Commissioning tests on Unit 1 showed that the 13.8 kV class IV power slow transfer was not satisfactory because not all the motor loads could be re-accelerated successfully. Class IV power, which is generated by the unit or supplied from the electrical grid, supplies the electrical loads on the station. The same deficiency was also found in Unit 2. A solution to this problem is currently being studied by Ontario Hydro. This design deficiency needs to be corrected by Ontario Hydro as soon as possible to ensure the reliability of the electrical power system.

3.5.4 Major Mitigating Systems

Two significant events occurred in each of the Steam Generator Emergency Cooling System and the Inter-Unit Feedwater Tie (IUFT). These events were reportable under the conditions of the Darlington NGS 'A' operating licence. A summary of these reportable events is given under SER-90-035, SER-90-038, SER-90-041, and SER 90-078 in Appendix I.

A design deficiency in the IUFT has been found as a result of commissioning tests and operational experience. A design change to install more pneumatic valves to facilitate safety related system testing is being implemented. This will enhance its reliability in performing its safety related function as credited in the safety analysis.

3.6 Special Safety Systems

The AECB requires to be promptly informed of any Type 1 or Type 2 system faults. A Type 1 fault is one that would significantly reduce the effectiveness of the system such that it would have been of little or no benefit if the worst possible process system failure had occurred. A Type 2 fault is one that would reduce the effectiveness of the system such that it would fail to satisfy the design intent, but would still operate and provide significant benefit. A number of Type 1 and Type 2 impairments to three of the four special safety systems (Shutdown System One (SDS1), Shutdown System Two (SDS2), Negative Pressure Containment (NPC)) occurred during 1990.

3.6.1 Shutdown Systems (SDS1 and SDS2)

There were two instances where impairment of shutdown system trip parameters occurred. The moderator low level trip instrumentation for SDS2 (Unit 2) was unavailable for 13 hours due to problems and follow-up maintenance activities associated with the reference legs of the instrumentation.

During a reactor physics commissioning test on Unit 1, the SDS1 temporary log neutron power trip was made unavailable for about 4 hours as a result of

operation of the Primary Heat Transport (PHT) pumps without disabling the PHT flow signals to the SDS1 trip computers. This was a Type 1 fault of SDS1 due to the impairment of a trip parameter required by the operating licence. An Ontario Hydro investigation identified lack of communication of licensing requirements to affected staff in the technical and production sections as a contributing factor to this incident.

AECB staff has reviewed the investigation report of this impairment prepared by Ontario Hydro, and has a different opinion about the root causes identified. AECB staff believes that insufficient attention was given to tracking the development of the work plan. Inadequate methods to allow for the approval of a work document, inadequate dissemination of licensing requirements and ineffective team work at the supervisory and management levels were also considered causal factors. Ontario Hydro was therefore requested to further review the areas of weakness identified.

3.6.2 Emergency Coolant Injection (ECI) System

There were no reported Type 1 or 2 faults of the ECI system during 1990.

3.6.3 Negative Pressure Containment (NPC)

An initial containment leak rate test on Unit 1, performed in June 1990, yielded a leak rate at vacuum which was considerably higher than that at positive pressure. The test results cannot support the assertion that the leak rate measured quarterly at vacuum during normal operation is representative of the leak rate under accident conditions during which the containment pressure might become positive. During the test, Ontario Hydro staff failed to follow some steps in the test plan to quantify the leakage between Unit 1 and Unit 2 containment. In addition, Ontario Hydro failed to attempt to identify the leaking components, which caused the discrepancy in the test results, before the test facilities were dismantled. Because the test results were found to be unacceptable to Ontario Hydro's designers, a second leak rate test to identify the leaks was performed in August 1990. After re-caulking several piping penetrations in the shutdown cooling room and repairing a defective O-ring on a valve in the east transfer chamber door's seal, the leak rate obtained at vacuum was found to be agreeable with that obtained at positive pressure.

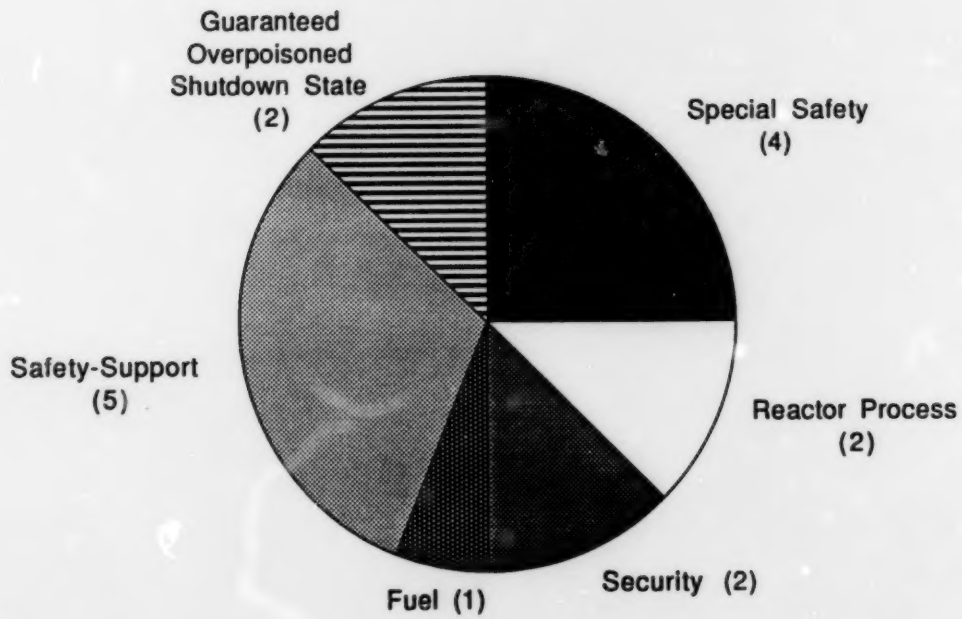
A type 2 fault of the NPC system occurred when a spurious button-up of the upper vacuum structure caused the upper vacuum chamber pressure to rise above the OP&P limit of 13.5 kPa(a). The fault was traced to a defective connector in the programmable controller controlling one of the button-up valves. Repairs were initiated to correct the problem and the pressure returned to its required value within eight hours.

3.7 Significant Events

A total of eighty-eight (88) significant events were reported in 1990; sixteen (16) of them were reportable under conditions of the DNGS 'A' operating licence. A brief description of each of the significant events pursuant to the Darlington NGS 'A' Operating Licence is given in Appendix I.

Of the reportable events, seven (7) involved violation of the Operating Policies and Principles and two (2) involved security. The reportable events are categorized in the following chart:

REPORTABLE EVENTS CHART



The total number of events is considerably higher than the forty-three (43) reported in 1989. With the completion and start-up of Darlington's second reactor this is not unusual; however, there were 25 human errors reported in the SERs in 1990, mainly in the areas of work practices and training and, although less than in previous years, there were a number of work protection and worker safety events which were mainly due to failure to follow procedures.

As discussed in section 3.9.1, SER 91-011 is an example of an event caused by backlogged maintenance. The underlying cause is the tardiness of taking action as evidenced by the large number of outstanding work packages, temporary operating memos, licensing commitments and Action Item responses. Improvement in all these areas is necessary.

The rather large number of events involving violation of the OP&P indicates that the shift staff should be furnished with more knowledge of the safety related information as documented in the safety report and other licensing submissions; in particular, the safety reasons for the values chosen in the Appendix B of the OP&P and the Abnormal Incidents Manual. It is understood that Darlington operations management plans to have designated technical support staff to work with each shift on a continuous basis to assist in solving safety related issues. AECB staff endorses this effort.

3.8 Quality Assurance

Revision 6 of the Darlington NGS 'A' Operating Quality Assurance Manual was issued in late 1989 and was reviewed by AECB staff in 1990. Except for a section dealing with procurement, which AECB staff is pursuing separately, the revised manual was found to be acceptable for implementation. Approval of this manual was given to Ontario Hydro recently.

The AECB audit of the Construction Quality Assurance Program was conducted in January 1990. This audit reviewed topics such as hydrostatic testing, welding, inspection, test and operating status, post weld heat treatment, cleanliness and steam generator internal inspection. Four recommendations were contained in the audit report and Ontario Hydro responded to these in April 1990. The responses were considered generally satisfactory although AECB staff intends to further scrutinize the application of certain welding procedure specifications where notch toughness is required. Overall, AECB staff is satisfied that construction of Darlington NGS 'A', in the areas audited, meets acceptable standards.

AECB staff also conducted an audit of the Operations Quality Assurance Program in April, 1990. Quality Observation Action Notices were raised in the areas of Deficiency Reports, Temporary Design Changes (Jumpers), Maintenance Program and Call-Ups. The corrective actions, carried out or proposed by Ontario Hydro in response to the audit report, were judged to be satisfactory in the areas of Jumpers and Call-Ups and the respective Action Notices were closed.

The Action Notices for Deficiency Reports and Maintenance Program remain open. Overall, AECB staff is satisfied that operation of Darlington NGS 'A', in the areas audited, meets acceptable safety standards.

Eight Quality Observation Recommendations were also raised as a result of the Operations QA Audit. The responses to these by Ontario Hydro were considered acceptable except for one relating to the lack of Level 3 station specific training at Darlington. AECB staff will be following this topic as part of a generic issue regarding the reorganization of training programs at all Ontario Hydro nuclear stations.

A quality improvement program (QIP) was initiated at the station in 1990. The following improvement teams were formed or being formed at year end: housekeeping, facilities, work assignment and work environment. It is too early to see any improvement as a result of the effort by these teams.

In 1990, the Quality Assurance Section staff at the station reduced from four to three. This reduction has resulted in fewer internal audits and assessments being conducted than planned. This is not acceptable in our opinion. With the above exception, AECB staff is of the opinion that Ontario Hydro has an acceptable Quality Assurance Program.

3.9 Maintenance/Operation

3.9.1 Example of A Significant Event Related to Backlogged Maintenance

SER 91-011 - ECI Testing: During an Emergency Core Injection Safety Related System Test (SRST) performed in 1989, a valve was found to be passing. It was reported as a deficiency and all 9 subsequent tests completed during 1989, 1990 and 1991 were performed using another valve in place of the first valve without appropriate approvals, a repeated violation of OP&P 01.6. Although there were other root causes, a contributing factor to this event was the fact that the original valve remained unrepaired for almost 18 months.

3.9.2 Routine Call-Ups

With the exception of operators at 73%, all other major work groups consistently achieved well above the 85% target completion rate. A determined effort is being made to improve the operator's completion rate by more effective scheduling, combining some call-ups and eliminating others. An increase in field operator experience gained during a complete year of operation with running units should also contribute to more efficient production in this area for 1991.

3.9.3 Outstanding Work Packages (WPs)

(includes Deficiency Reports, Call-Ups, Work Plans etc.)

Work Group	*Outstanding WPs*	*Net Change (yr)*	*% Change (yr)*
Operators	781	+297	+38%
Service Maintenance	1192	+314	+27%
Mechanical Maintenance	702	+288	+41%
Control Maintenance	2788	+1005	+36%
Technical Unit	5834	+1668	+29%
Other	486	\	\
All	11783	+ 3572	+30%

In all areas, the already large number of outstanding work packages is increasing.

3.9.4 Documentation Status

A significant number of operating memos were in force as of December 31. Additionally, a large number of operating memos were in effect as of the same date for periods exceeding 6 months. Furthermore, as can be seen in section 4.1 of the Appendix II, many operating memos had not been reviewed within the time allotted.

This is unsatisfactory and as such Ontario Hydro is required to make significant reduction in all section 4.1 categories in 1991.

3.10 Chemistry Control

The average overall station chemical control performance standard throughout 1990 was achieved 90% of the time against a target of 95%. Chemical control performance in the Primary Heat Transport (PHT) System of Units 1 and 2 was 69% and 82%, respectively. The main problem in this system is dissolved deuterium control, which was achieved only 18% and 40% of the time, respectively in each unit.

Modifications to the Hydrogen Addition System to provide better flow control, and to the Purification Sampling System to provide more representative samples are in progress. Therefore, AECB staff expect to see improvements in performance in this area during the coming year.

3.11 Station Management

AECB staff has continued to receive good co-operation from Ontario Hydro staff at all levels. Communications have been effective. Advance notification of potential safety concerns and licensing issues, and prompt notice of safety significant events or planned activities has been consistently provided by station management. This excellent cooperation continues to be appreciated by the AECB project staff.

3.12 Training

AECB staff is aware that the development and implementation of an effective and comprehensive training program is time-consuming and resource intensive and recognizes the efforts made in 1990 by Ontario Hydro and Darlington NGS 'A' staff towards these goals. This work should be continued in 1991 with improvements for example to fuel handling operator and other work group training.

3.12.1 Authorization Training

Authorization training for Shift Supervisors (SS), and Control Room Operators (CRO) continued with the following results; five out of five SS candidates passed the June, Nuclear General examination, twelve out of fourteen SS and CRO candidates passed the November, Conventional Specific examination and four candidates achieved conditional passes for the Conventional General examination written last October.

3.12.2 Refresher Training and Requalification

Refresher training also continues with each crew performing two 4-day sessions per year, all of which were run by Darlington NGS 'A' and Eastern Nuclear Training Department (ENTD) training staff. In 1990, AECB project staff observed some of this training at the Darlington NGS simulator located at ENTD. Ontario Hydro has indicated that the assessment and requalification process requires further development before being implemented formally. AECB staff regards periodic assessment and requalification of AECB authorized staff as being of high importance. As such, Ontario Hydro should complete this development and implement this program as a priority matter.

3.12.3 Training for Other Work Groups

Training of other work groups, including the lower operator ranks, remains heavily backlogged. Most noteworthy are the areas of Control Maintenance (CM) field checkouts at a completion rate of only 0.05%, and Level 4 Station Systems with a backlog of almost 2000 training person-weeks. Thirteen hundred of the latter represent station specific training for operators possessing Nuclear Operator level 4 accreditation from other stations.

New hires, plant commissioning and unusually high staff turnover in some work groups (e.g. Control Maintenance), have been given as reasons for this backlog; however, the Darlington NGS Training Unit has informed AECB staff that steps are being taken to ameliorate this situation in 1991.

3.12.4 Fuel Handling Training

The quality of the fuel handling training manuals is far below that of other station systems. Poor quality manuals are symptomatic of the many deficiencies in the overall Fuel Handling Training Program. Indeed, substandard training appears to have exacerbated the consequences of the current damaged fuel problem in Unit 2.

The dedicated in-station group assigned to this fuel problem has given high priority to rectifying these training problems. The recent hiring of two ex-Ontario Hydro personnel, both of whom have considerable fuel handling experience at other stations, is one of the steps that has been taken in an effort to significantly improve this program.

It is worth noting that six of the nine currently qualified fuel handling operators have had the benefit of being trained at other stations.

3.13 Emergency Drills and Practices

A comprehensive program of emergency drills and practices involving all crews and dedicated teams was completed in 1990, as shown:

EVENT	#PERFORMED	NOTES
Reactor Drills	8	Included coincident fire and contaminated casualty incidents. Required initiation of Radiation Emergency Procedures.
Accounting Drills	5	
Transportation Emergency Response Drills	11	On-site only.
Tritium Removal Facility Drills	5	
Off-Site Survey Team Practices	16	
Emergency Response Team Practices	16	Included various combinations of fire, first aid, hazardous material response and search and rescue scenarios.

All drills were evaluated by the Station Safety Section (SSS). All practices were evaluated by the individual crew Shift Supervisors. One of the eight full scale reactor drills was a surprise drill evaluated and initiated by Ontario Hydro's Nuclear Operating Standards Division without the prior knowledge of the SSS. This latter drill included the deployment of the Site Management Group.

All crews, including the day/administration G-crew Emergency Response Team, have completed at least the required number of drills and practices. The most noteworthy outcome of all of these activities has been the realization at site of the requirement for significantly greater involvement of the Town of Newcastle Fire Department in the reactor drills. This will be manifested in the 1991 program. Overall, AECB staff is pleased with the effort made by Ontario Hydro in completing this program.

3.14 Security and Safeguards

3.14.1 Security

There were two security incidents during 1990. Both involved acts of malevolence during labor unrest in the spring of 1990.

During the year, security staff, together with other security forces, carried out one intrusion exercise. As a result of this exercise, AECB staff identified to Ontario Hydro a number of deficiencies for immediate remedy.

Also during the year, AECB staff carried out a compliance inspection of the security perimeter which had been extended to include Unit 1. Again, a number of deficiencies were identified for remedial actions.

Lastly, Ontario Hydro submitted two security reports in 1990: the first was an annual report to cover the preceding calendar year, while the second was required to incorporate Unit 1 under the interim security plan. Apart from some minor comments, both reports were found to adequately comply with the regulatory requirements stipulated in section 34 of the Physical Security Regulations.

3.14.2 Nuclear Fuel Safeguards

A safeguards plan for a nuclear power station is required to fulfill Canada's obligations under the Nuclear Non-Proliferation Treaty. The Safeguards Plan Rev. 1 for Darlington was submitted to the AECB in late 1989. AECB staff assessment of that plan concluded that it contained all the basic elements necessary for the safeguards program currently being applied to the Darlington facility. However, AECB staff proposed wording changes to the document to ensure that the Safeguards Plan reflects a direct licensing relationship between the AECB and the Darlington facility. A revised version of the Safeguards Plan was submitted recently and is currently being reviewed.

A secondary document, the Safeguards Implementation Plan, which is referenced in the Safeguards Plan, is being drafted to give the necessary details for efficient implementation of the safeguards measures.

3.15 Inspections by AECB Staff

3.15.1 Rounds

AECB project staff completed a series of compliance inspection (Rounds) in all nuclear plant areas and most exterior buildings according to the frequency set out in Power Reactor Division procedures. Substandard housekeeping was the most frequent find, followed by inconsistant adherence to Radiation Protection Procedures and tagging (equipment identification). Shift response to these findings was generally prompt and effective.

When time and work load permit, significant effort will be put into development of System Inspections (SI) and Operating Practice Assessments. At year's end, only SIs for Class I and II power and Negative Pressure Containment had been completed.

3.15.2 Housekeeping

With the exception of the TRF/Heavy Water Management building (HWMB), housekeeping in all parts of the station operating island was generally good. Recently, improvements in housekeeping in the TRF/HWMB have been noted.

3.16 Testing

Darlington NGS 'A' Safety Related System Test (SRST) completion performance improved significantly in the latter half of 1990. A total of 66 out of the approximately 4700 tests that were scheduled were not completed as required. Many of the former number were not done due to circumstances that appear to have been easily avoidable.

The quarterly non-completion rate of tests increased from 2.1% in the first quarter to 2.8% in the second quarter. During the last two quarters, the non-completion rate dropped to a more satisfactory 0.3%. This trend should continue in 1991 as the reasons for 75% of the non-completed tests, namely the unavailability of the auxiliary boiler feed sub-system and faulty and/or non-existent procedures, have been dealt with.

3.17 Measures of Station Performance

The AECB 1990 performance indicators and other objective measures are presented in Appendix II. It should be noted that the assessment arrived at may not be based on any established criteria but represents a "consensus" view of the AECB staff members who were most closely involved with the operation of the plant in 1990.

4. SIGNIFICANT LICENSING MATTERS

The following twelve significant licensing issues were dealt with during 1990:

A-III-1 -Issuance of Unit 1 Licence
A-III-2 -Licensing Commitments and Action Item Responses
A-III-3 -Shutdown System Software

A-III-4 -Waterhammer Associated with Emergency Core Cooling Operation
A-III-5 -Heat Transport System Waterhammer Stress Analysis
A-III-6 -Fuel Bundle and Fuel Handling Machine Problem
A-III-7 -Waterhammer Concern Associated with Water Injection to Steam Generators
A-III-8 -Generator Rotor Crack
A-III-9 -On-Power Refuelling
A-III-10 -New Operator Family
A-III-11 -Control Room Staffing
A-III-12 -Tritium Removal Facility

The details of these issues are presented in Appendix III. Adequate progress has not been made on items A-III-2 and A-III-5.

5. COMMISSIONING AND CONSTRUCTION ACTIVITIES

AECB staff considers that, in general, the construction and commissioning of Darlington NGS 'A' units have been, and continue to be, carried out in a competent and professional manner.

5.1 Unit 3

During 1990, construction of the unit progressed at a rapid pace. By year end, the system turnover to Operations totalled 121 systems (out of 176 systems required), of which 40 were accepted. Commissioning of nine systems was completed, and was in progress for most support systems (air, water and electrical). Recently, the unit passed the first licensing milestone with the D_2O fill of the moderator system.

The second licensing milestone is fuel loading, which is expected to begin on January 1, 1992, with a predicted first criticality date of April 1, 1992.

5.2 Unit 4

Construction of Unit 4 during 1990 also progressed rapidly. By year end, turnover of eight systems had been offered to Operations and one formally accepted. The commissioning of the unit control computers was well advanced. Fuel loading is expected for October 1, 1992 and first criticality by January 1, 1993.

6. DESIGN RELATED ISSUES

During construction, commissioning and the initial stages of operation at Darlington NGS 'A', there have been a number of design related problems.

- heat transport system piping restraints
- shutdown system trip computer software
- generator rotor cracks
- fuel bundle end-plate cracking problems in Unit 2
- shutdown cooling room design problems
- waterhammer associated with water injection into steam generators
- emergency coolant injection waterhammer concerns

This appears to be a greater number of issues than previously noted at other stations, thereby suggesting some deficiencies in the design process.

7. CONCLUSION

It is the opinion of AECB staff that, overall, the operation of the station by Ontario Hydro during 1990 met acceptable safety standards. Despite the numerous problems and technical difficulties encountered during the year, notably the core damage in Unit 2 and the cracks found in the generator rotor, AECB staff believes that station management and supervisory personnel have, on the whole, acted with due caution and made decisions with safety as a primary consideration.

The exception to this general conclusion was the decision to request approval for the restart of Unit 1 before establishing the cause or extent of damaged fuel.

APPENDIX I
Reportable Events

SER 90-003 February 3
LEVEL 2 IMPAIRMENT OF SDS LOW MODERATOR LEVEL TRIP

A Type 2 fault of SDS2 moderator low level trip occurred during maintenance on the moderator level transmitters of Unit 2. The implied level of all three transmitters increased from 8600 mm to 8900 mm in response to "pumping up" of the reference legs, which is a deviation in the unsafe direction. This event was reported to the AECB pursuant to licence condition A.A.19(vii), as a potential failure of a special safety system to perform in accordance with the Safety Report.

SER 90-006 February 8
MBFP P4 CRACKED WELD

A crack leaking steam and water was found in the weld joining the suction of the relief valve line to the main suction line of the main boiler feed pump. The cause appears to be fatigue failure. The event was reported to the AECB pursuant to licence condition A.A.19.(i).

SER 90-016 March 30
SECURITY

Security events are not described in this report.

SER 90-017 April 12
SECURITY

Security events are not described in this report.

SER 90-018 April 11
MAINTENANCE ON NEUTRONIC MEASUREMENT INSTRUMENT WHILE IN GUARANTEED OVERPOISONED SHUTDOWN STATE

Maintenance was performed on an SDS1 Ion Chamber Amplifier with the unit in the guaranteed shutdown state. OP&P 03.1 specifies a "high power state" for maintenance on SDS neutron power instrumentation unless otherwise approved on a case-by-case basis by the Station Manager and AECB. An operating memo had been issued giving station manager approval for this maintenance without being at high power, which is an apparent violation of the case-by-case intent of OP&P 03.1. This event was reported to the AECB pursuant to licence conditions A.A.19(vii) (described above) and A.A.1, as a violation of the Operating Policies and Principles.

SER 90-020 April 19
MODERATOR SAMPLING SYSTEM BYPASSING G.O.S.S.

Condition Guarantee No. 1 of the guaranteed overpoisoned shutdown state (GOSS) (main moderator isolated from purification) was violated on Unit 2. The moderator D_2O Sampling System was found to bypass guaranteed devices. At the time that this was discovered, no actual flow path existed; the sampling lines represented a potential flow path only. This event was reported to the AECB pursuant to licence condition A.A.19(vi).

SER 90-035 June 22
IUFT ABFP UNAVAILABLE FOR AUTO START

The Unit 1 auxiliary boiler feedwater pump (ABFP) was inadvertently inhibited from being available for automatic startup on an inter unit feedwater tie (IUFT) signal from Unit 2. This condition existed for approximately four hours and was attributed to inadequate verification of system alignment. The event was reported to the AECB pursuant to licence condition A.A.1.

SER 90-038 July 17
SER 90-041 August 2
OP&P VIOLATION ON SGECS

On two occasions high levels in water storage tanks resulted in a violation of OP&P B.43.2. The consequence of high water levels is the unavailability of the Steam Generator Emergency Coolant Injection System (SGECS); the upper limit on storage tank levels is required to ensure adequate air volume during SGECS injection. This event was reported to the AECB pursuant to licence condition A.A.1.

SER 90-048 September 5
HIGH UPPER VACUUM CHAMBER PRESSURE

The upper vacuum chamber (UVC) pressure rose above the Level 2 impairment value of 13.5 kPa (specified in OP&P B.34.2.1) due to a spurious button-up of the vacuum system. The root of the problem was a programmable controller hardware fault. This event was reported to the AECB pursuant to licence condition A.A.1, as a violation of OP&P 34.2.1 (Negative Pressure Containment availability). The significance of this event is that dousing would have been delayed in the event of a loss of coolant accident.

SER 90-057 September 18
HEAT TRANSPORT PUMP SUSTAINED LP TRIP IMPAIRMENT

Upon cancellation of a jumper, four pressure switches used for the heat transport pump sustained low pressure trip were not returned to their required values. The event was reported to the AECB pursuant to licence condition A.A.19.(vii).

SER 90-072 October 19
STANDBY GENERATOR #1 DAMAGE

Significant damage to the first stage turbine rotor blades was discovered on standby generator No. 1 during a maintenance outage. The standby generator could not be run safely with this damage. The event was reported to the AECB pursuant to licence condition A.A.19(i).

SER 90-078 November 6
IUFT IMPAIRMENT

The Unit 1 supply valve to the inter-unit feedwater tie (IUFT) header failed to open during the commissioning of valve limit switches, thus rendering IUFT unavailable for Unit 2 (Type 1 fault). This event was reported to the AECB in the fourth quarterly report for 1990.

SER 90-080 November 7
POSSIBLE IMPAIRMENT OF SDS1

A possible Level 1 impairment of the temporary log N trip required on SDS 1 occurred during reactor physics commissioning tests. (It was an AECB requirement that the approach to criticality be conducted with both 'hardwired' and software based SDS trip loops.) The event was reported to the AECB pursuant to licence condition A.A.19(vii).

SER 90-086 November 2
0.5% DEPLETED BUNDLES LOADED INTO UNIT 1

During reactor physics commissioning tests on Unit 1, flux scans revealed an unexpected bottom-to-top neutron flux tilt. This condition was traced to the loading of a mixture of 0.4% and 0.5% U_{235} depleted fuel bundles in Unit 1 in August 1990. This event was reported to the AECB pursuant to licence condition A.A.19(ii).

SER 90-088 December 30
APPARENT VIOLATION OF OP&P 30.1 (f)

OP&P 30.1(f), which requires the reactor to be maintained either critical or in a guaranteed shutdown state, or in an active transition to one of those conditions was violated. The reactor was found to be subcritical when liquid zone levels did not respond to a small reactor power increase. The event was reported to the AECB pursuant to licence condition A.A.1 as a violation of the Operating Policies and Principles (OP&P).

APPENDIX II
OBJECTIVE MEASURES OF STATION PERFORMANCE
DARLINGTON NGS 'A'

		LAST YEAR'S VALUE	ACCEPTABLE	NEEDS ACTION
1.	RADIATION CONTROL			
1.1	Occupational Safety			
1.1.1	Total Whole Body Dose 105 mSv	31.5 mSv	X	___
1.1.2	Total Extremity Dose 19.7 mSv	3.6 mSv	X	___
1.1.3	Total Neutron Dose 3.0 mSv	2.0 mSv	X	___
1.1.4	Total Additional Skin Dose 14.4 mSv	1.4 mSv	X	___
1.1.5	Total Tritium Gas Lung Dose 4.8 mSv	4.2 mSv	X	___
1.1.6	Number of Exposures Exceeding Regulatory Limits	0	X	___
1.1.7	Number of radiation related supervisor's investigations 7	NA	X	___
1.2	Public Safety			
1.2.1	Releases from the Station			
	a) Airborne			
	Tritium (oxide) No of weeks >1% DEL 0	0	X	___
	Average % DEL for year 5.5×10^{-2}	7.2×10^{-2}	X	___
	Tritium (elemented) No of weeks >1% DEL 0	0	X	___
	Average % DEL for year 5×10^{-4}	1.8×10^{-3}	X	___
	Noble Gas No of weeks >1% DEL 0	0	X	___
	Average % DEL for year 0.010	N.D.	X	___
	Iodine 131 No of weeks >1% DEL 0	0	X	___
	Average % DEL for year 0.002	N.D.	X	___

1.2.1 Continued	LAST YEAR'S VALUE	ACCEPTABLE	NEEDS ACTION
Particulates No of weeks > 1% DEL 0	0	X	___
Average % DEL for year 0.001	N.D.	X	___
b) Waterborne			
Tritium No of months > 1% DEL 0	0	X	___
Average % DEL for year 1.7×10^{-3}	8.9×10^{-4}	X	___
Gross β No of months > 1% DEL 0	0	X	___
Average % DEL for year 0.0192	N.D.	X	___
c) Total Heavy Water Loss 7495 kg (if excessive, should be reflected in higher tritium releases)	11256 kg	X	___
d) Critical Group Dose (Infant) 10 μSv	NA	X	___
e) Total Population Dose 0.124 person-Sv	NA	X	___
1.2.2 Environmental Measurements			
Average Boundary dose rate 43.2 nGy/hr (Acceptable if within range of provincial reference sites value and not a significant increase from previous years)	NA	X	___
Average Boundary Tritium in Air 0.9 Bq/m^3 0.1% MPCa converted to Bq/m^3 (> 15 Bq/m^3 would indicate a marked increase and would require investigation)	NA	X	___
Average Tritium Concentration in Precipitation 50 Bq/l (average of all measurement sites)	NA	X	___
Average Gross β in Precipitation 24 Bq/m^{-2}/month	NA	X	___

		LAST YEAR'S VALUE	ACCEPTABLE	NEEDS ACTION
1.2.2 Environmental Measurements cont.				
Average Tritium in Milk	11 Bq/l	NA	X	___
Average C14 in Milk	285 Bq/kg	NA	X	___
Average I131 in Milk	≤0.17 Bq/l	NA	X	___
Average Tritium in drinking water	14 Bq/l	NA	X	___
Average gross β in drinking water	0.12 Bq/l	NA	X	___

Local water and fish samples

Specific items for comment: Fish samples came from only a short period, 15-17 October 1990. Frequency of fish sampling should be increased to better cover the whole year.

Terrestrial Samples

Specific items for comment: Tritium concentrations in honey and grass appears to be about a factor 2 higher in the western sectors than that in any of the other sectors.

2. Plant Control		LAST YEAR'S VALUE	ACCEPTABLE	NEEDS ACTION
2.1	Number of non-spurious Reactor Trips/Unit 1	NA	No Comment	
2.2	Number of Serious Process Failures/Unit 0	NA	X	___

2.3 Special Safety System Unavailability (Target = 10^{-3} Years/Year)

	This Year			Last Year			Predicted Future		
Unit:	0	1	2	Unit: 0	1	2			
SDS1	NA	0.457	0	NA	NA	0	0.432	X	___
SDS2	NA	0	1.48	NA	NA	0	0.496	___	X
Containment	0	0	0	0	NA	0	1.0	X	___
ECI	0	0	0	0	NA	0	1.0	X	___

2.4	Number of Reportable Incidents/Unit* 5	_____	X	___
2.5	Number of Fires 1 (Based on SERs only)	0	X	___
2.6	Number of Significant Human Errors Reported 25	16	___	X

* Including Unit 0

			LAST YEAR'S VALUE	ACCEPTABLE	NEEDS ACTION
3.	Plant Maintenance				
3.1	Number of Unplanned Outages/Unit	3	NA	X	
3.2	Number of Call-ups Outstanding at year-end	32	NA	X	
3.3	Average of Monthly Deficiency Reports Outstanding/Unit*	300	NA		X
4.	Plant Administration				
4.1	Documentation				
4.1.1	Average No. of Operating Memos in force/unit* on 31 December	54	NA		X
4.1.2	Number of Memos extant > 6 months	62	NA		X
4.1.3	No. of systems (USI) with >1 Op Memo extant	3	NA		X
4.1.4	No. of Operating Memos behind schedule for review	32	NA		X
4.1.5	Total number of jumpers:	2152	NA		X
4.2	Training				
4.2.1	% Scheduled drills completed	100	NA	X	
4.2.2	% Candidates passing AECB exams	91%	NA	X	
4.3	Security				
4.3.1	Number of reportable security events	2	NA	X	

* Including Unit 0

4.4 Quality Assurance

	ACCEPTABLE	NEEDS ACTION
4.4.1 Results of AECB Audits		
1) Date January 22-24, 1990 (construction audit)	X	___
2) Date April 23-27, 1990 (operations audit)	___	X

APPENDIX III
Significant Licensing Matters

A-III-1 Issuance of Unit 1 Licence

In 1990, AECB staff continued monitoring the design, construction and commissioning activities performed by Ontario Hydro in Unit 1. The progress in design and construction was found to be satisfactory. It was also found that commissioning activities had generally been carried out in a competent and professional manner, with the exception of the containment leak rate test which is described in section 3.6.3. Approval for fuel loading and heavy water loading into the heat transport system was given on August 1 and August 27, 1990 respectively.

With the effort of Ontario Hydro and AECB staff, six specific issues related to Unit 1 operation were resolved in a timely fashion. Approval to allow low power operation of the Unit 1 reactor was issued on October 26, 1990.

After the start of low power operation, some non-standard depleted fuel was found in Unit 1 reactor as a result of physics measurements (see section 3.5.1 for details). A meeting was called to discuss the potential impact of the depleted fuel on the maximum bundle power, the maximum channel power and the effectiveness of reactor regulating system during operation with a pre-equilibrium core. An assurance, substantiated with detailed analysis, was given by Ontario Hydro that a reduction in neutron overpower setpoints was not required for this non-standard depleted fuel configuration in the reactor core of Unit 1. Approval to raise power to 100% full power was therefore given on January 6, 1991.

A-III-2 Licensing Commitments and Action Item Responses

Frequently licensing issues are resolved by the commitment of Ontario Hydro to do analyses, experiments, commissioning tests, regular safety related system tests and maintenance call-ups,or to implement design or operating procedure changes. The records of these commitments are stored in Ontario Hydro's computer management system and are periodically reviewed to track their progress.

Many Darlington licensing commitments are now completed. There remain, however, a significant number of commitments still outstanding and some were overdue at end of 1990. Some examples of these are given below:

(i) A commissioning test to simulate main control room box-up under toxic gas conditions will be completed before the Unit 2 in-service date.

(ii) A program will be in place by the Unit 2 in-service date for in-service testing of containment isolation valves (other than button-up valves).

(iii) A program will be in place to periodically review the calibration of instruments by which safety parameters are measured, so as to

(iii) A program will be in place to periodically review the calibration of instruments by which safety parameters are measured, so as to ensure that the requirements given in section 3.1 of the Operating Policies and Principles are met.

(iv) An operating procedure will be implemented that will ensure that 24 hours after a loss of coolant accident, one low pressure Emergency Core Cooling pump will be left islanded on class III power, and another pump will be left operating via class IV power to assure no interruption of emergency core cooling operation.

(v) Confirmation will be made by commissioning test data that the uncertainty due to use of computer code OHRFSR is within ±3.5% for detector readings and ±2.5% of calculated channel power response.

(vi) Heat transport system water hammer analysis (see A-III-5 for details).

AECB staff expects more effort to be given by Ontario Hydro to fulfill the licensing commitments in a timely fashion.

In 1990, 13 licensing action items were opened. At year end, 2 were closed and 6 had no response from Ontario Hydro. These 6 items together with their open and first response dates are given below:

	Item	Open Date	First Response Date
(i)	safeguards plan	May 10, 1990	March 28, 1991
(ii)	safe pathway for operator action following common mode events	June 7, 1990	April 10, 1991
(iii)	SGECS/ESWS/IUFT waterhammer	November 1, 1990	March 15, 1991
(iv)	valve position assurance	May 24, 1990	no response yet
(v)	information required for approval of proposed change	July 27, 1990	no response yet
(vi)	on-power refuelling	November 21, 1990	no response yet

It is the AECB staff's view that, in general, Ontario Hydro has not been able to respond to the action items in a timely fashion. More effort is required for improvement in this area in the coming year.

A-III-3 Shutdown System Software

The review of software for both shutdown systems was successfully completed in February 1990. AECB staff has concluded that the current version of the software for the shutdown systems is acceptable and safe, but that it will be difficult to maintain and therefore is not suitable for use in the medium to longer term. As a result, a licence allowing unit 2 reactor to raise power to 100% FP was issued on condition that the existing shutdown system software be redesigned and that before redesign is undertaken, an appropriate standard be defined.

At present, Ontario Hydro and AECL are developing methods for specifying, designing and verifying safety critical software. These methods will be applied to the development and verification of some prototype systems before they are adopted for general use or for the redesign of the Darlington shutdown systems. The goal of these methods is to make software easier to modify, verify, and review. The AECB staff is monitoring this process closely. As of December 1990, three drafts have been issued and reviewed.

In parallel, the AECB staff is doing research and is monitoring international development regarding standards for safety critical software in nuclear power plants. This will enable AECB staff to evaluate the acceptability of the standard to be defined for redesign of the Darlington shutdown system software.

In 1991, it is expected that Ontario Hydro and AECL will develop more detailed methods and tools for specifying, designing and implementing safety critical software. The AECB staff will be reviewing these methods and tools to ensure the incorporation of quality assurance, and to ensure that the product will be reviewable and verifiable.

A-III-4 Waterhammer Associated with Emergency Core Cooling Operation

For Unit 2 Operation, a large number of piping supports were installed in the emergency core cooling (ECC) system to alleviate the concern over waterhammer which could occur as a result of void collapse due to loss of power and the subsequent pump restart. For Unit 1 operation, an extension of the ECC system to include Unit 1 piping was required. However, a design analysis showed that with the added Unit 1 piping the critical stress points would move and the stress level in some portions of the piping would exceed allowable limits if waterhammer occurred. Hence, the waterhammer associated with ECC operation became one of the issues requiring resolution prior to Unit 1 operation.

An engineering study was conducted by Ontario Hydro in order to solve the problem. It was found that installation of more piping supports to withstand the dynamic impact of waterhammer was neither practical nor economical. Ontario Hydro therefore proposed to modify the ECC system by introducing water

from the emergency service water system to refill the piping void prior to restart of the ECC pump. This modification would significantly reduce the severity of waterhammer impact and maintain the piping stress in the ECC system of Units 1 and 2 within allowable service limits.

AECB staff reviewed the design modification with Ontario Hydro engineers to ensure that the licensing requirements given in AECB consultative document C-9 were met. Approval of the proposed modification was then given to allow for installation. A commissioning test was also conducted to confirm its operational and functional capability prior to issuance of the Unit 1 operating licence.

A test on ECC system check valve slam was also performed at Ontario Hydro's Research Laboratory in November 1990. The results demonstrated that the integrity of the ECC system check valves would be maintained under the waterhammer transient conditions.

When the ECC system is extended for operation of Units 3 and 4, it is expected that further analysis will be performed to confirm that the piping stress is still within allowable service limits in the event that waterhammer does occur in the ECC system.

A-III-5 Heat Transport System Waterhammer Stress Analysis

Waterhammer may occur in the heat transport system as a result of emergency core coolant injection following a loss of coolant accident. Thus, the dynamic impact of waterhammer on piping integrity has to be factored into the heat transport system design.

Prior to issuance of the operating licence for Unit 2 low power operation, the staff of AECB and the Ministry of Consumers and Commercial Relations of Ontario jointly granted a concession permitting heat transport system design registration without completion of the waterhammer analysis. The concession was based on the following commitments made by Ontario Hydro:

(a) to complete waterhammer analysis and issue the stress report by July 30, 1990, for an accident scenario with the heat transport system under relatively cold conditions.

(b) to complete a waterhammer analysis with heat transport system under hot conditions by 1991. This analysis, performed with appropriate computer code, is to confirm Ontario Hydro's assertion that the analysis performed for (a) above is adequate because the consequence of waterhammer analysis with the heat transport system under cold condition will bound the consequence for any scenario under hot conditions.

With respect to commitment (a) above, Ontario Hydro informed AECB staff in July, 1990 that the completion of waterhammer stress analysis would be delayed until December, 1990 due to heat transport system feedline relocation. There was no information submitted until mid-February 1991. AECB staff was then informed that the heat transport piping had met the ASME code requirements for

the level D service limits with the exception of three 2-inch pipes in the shutdown cooling system. Ontario Hydro indicated that the failure of these three pipes would have a negligible effect on the conclusion of accident analysis, and therefore a design change would not be warranted. Ontario Hydro did, however, find some problems associated with piping supports. A study to resolve the problem is currently in progress. AECB staff was to be informed of the outcome by May 1991. (To-date, this has not been received.)

With respect to commitment (b), AECB staff was recently informed that a verified computer code would be developed to perform the waterhammer analysis with the heat transport system under hot condition. The details of work scope and schedule were to be available by May, 1991.

AECB staff is of the opinion that the progress to resolve this issue is less than satisfactory because commitment (a) has not yet been completely fulfilled at present. In addition, it appears that only very limited progress has been achieved in fulfilling commitment (b). A significant effort is required to improve the current situation in order to resolve this issue in a timely fashion.

A-III-6 Fuel Bundle and Fuel Handling Machine Problem

On-power refuelling was proceeding normally in Unit 2 with 94 channels already fuelled, until November 30, 1990, when difficulties were experienced with one of the fuelling machines while locked onto channel N12. Debris from damaged fuel prevented the shield plug and the original closure plug from being reinserted into the end fitting, leaving the fuelling machine stuck onto the channel. A spare closure plug was locked into place on December 17, 1990, but the channel was still leaking. Early in the new year the reactor was shut down and a maintenance cap was installed to stop the leak. This enabled removal of the fuelling machine from the channel and restart of the reactor. However, it was realized shortly after restart that the debris from the damaged fuel did not come from the fuel bundles originally contained in the fuelling machine but from a fuel bundle still residing within the reactor core. The licensee immediately shut down the unit to perform channel inspections.

Following the incident of November 30, 1990, AECB staff questioned the licensee in a letter dated December 12, 1990, as to whether it would be prudent to shut down the unit until the condition of the damaged fuel had been ascertained. The licensee replied to our questions on January 4, 1991 and the unit was shut down one week later. AECB staff has formally asked Ontario Hydro to keep us fully informed of the unit status before it is allowed to restart.

A-III-7 Waterhammer Issue Associated with Water Injection to Steam Generators

In August, 1990 Ontario Hydro identified by analysis, the potential for a severe waterhammer transient on operation of the Steam Generator Emergency Cooling System (SGECS) at Pickering NGS. The waterhammer is attributable to vapor condensation arising from the pressurized cold water injection into the reheater drain piping, which would be primarily steam filled at the time of SGECS initiation.

At Darlington NGS there are three systems connected to the reheater drain piping to supply cooling water to steam generators under various accident conditions. These three systems are the Steam Generator Emergency Cooling System (SGECS), Emergency Service Water System (ESWS) and Inter-Unit Feedwater Tie (IUFT).

The waterhammer concern identified at Pickering prompted an inspection at Darlington site by AECB staff. This inspection revealed an inverted-U shape piping arrangement (from the SGECS and ESWS to the steam generator reheater drain nozzles), which is similar to the Pickering NGS arrangement and is a potential source for a waterhammer transient.

In view of the safety importance of the heat sink provided by the SGECS, ESWS and IUFT, and the waterhammer potential problem revealed from on-site inspection, AECB staff has requested Ontario Hydro to conduct an investigation and to provide the following for review:

(a) the operating conditions at the piping near the steam generator reheater drain nozzles where the cooling water will be introduced to the steam generators from SGECS, ESWS or IUFT for all accident events analyzed in the Safety Report;

(b) the piping stress levels reached under the conditions identified in (a) above;

(c) the proposed changes in design and/or operating procedure, if the piping stress levels exceed the allowable limits.

Based on the results of a preliminary analysis, Ontario Hydro has recently confirmed that a waterhammer transient resulting in piping failure could occur on initiation of the SGECS at Darlington NGS. The analysis to examine waterhammer impact on the piping of ESWS and IUFT is still in progress. Temporary measures to reduce waterhammer severity are being implemented to allow continued operation.

On completion of its investigation, Ontario Hydro is expected to respond to the items identified in (a), (b) and (c) above. It is also expected that the proposed long term solution should effectively eliminate any waterhammer concerns in the piping network of SGECS, ESWS and IUFT, and thus ensure the heat sink capability and reliability.

A-III-8 Generator Rotor Crack

Inspection of the Unit 2 generator on March 13, 1990 identified a crack in the generator rotor shaft. The inspection was performed because of the observed presence of abnormal bearing vibrations during an earlier turbine rundown.

The crack was located at the non-driven end of the generator shaft at the point where the electrical leads pass through the shaft. The crack was pie-shaped and extended approximately 25% around the shaft circumference. The failure mechanism was identified as initial fretting damage at the retaining nut threads, which resulted in multiple surface cracking. Under the very high localized bending stress which existed in that region, the cracks were propagated by high cycle fatigue. Modifications to the rotor design were performed to correct the problem.

As a result of this incident, Ontario Hydro has improved the Darlington turbine generator vibration monitoring system. With the improved system, the crack in March, 1990 would have been noted three days prior to the event. However, it should be noted that a substantial crack must be present (approximately 2 inches in depth) before the monitoring system which measures shaft displacement will detect any abnormal vibration.

Subsequent to this incident, further cracking problems with the Darlington NGS rotors were observed in March of this year (1991). The cracks (two) occurred in an area where fretting had been observed during the previous event. As part of the earlier modifications, these areas were polished; the fretting mechanism was thought to have been removed, but this obviously was unsuccessful. Examination of the cracks resulted in the conclusion that the cracks were propagating at a low rate by high cycle fatigue. Further design modifications are being planned to correct this deficiency.

There appears to be a basic design problem with the Darlington rotors, in that they incorporate a flexible shaft design. As well as being outside of previous experience, this design does not encompass a "defence-in-depth" approach. A "defence-in-depth" design should include: no known mechanisms which could initiate cracks in-service, a shaft demonstrably tolerant to small cracks, a system to identify the onset of failure, and finally, protection against the consequences of catastrophic failure if it were to occur. The Darlington rotors do not, for the most part, meet these requirements. Ontario Hydro recognizes the shortcomings of the rotor design and plans are being considered to replace all Darlington rotors with a newly designed rotor over the next few years.

A-III-9 On-Power Refuelling

In accordance with condition no. A.B.5 c) of Power Reactor Operating Licence 13/90, AECB staff first authorized on-power refuelling in Unit 2 on November 1, 1990, for one channel as a demonstration. The authorization was subsequently extended on November 10, 1990 to flow-instrumented channels to ensure adequate channel flow blockage detection, and finally to non-flow instrumented channels on November 21, 1990 after the licensee committed extra monitoring measures to detect flow blockage. An action was placed on the licensee to review with AECB staff the whole status of channel flow blockage detection before on-power refuelling is approved in the long term.

A-III-10 New Operator Family

This station has started to implement a new operating structure in the form of titles, wages and a few responsibility changes. The objective of this change is primarily to improve supervision of operating staff. A committee made up of AECB site staff from Ontario Hydro stations was formed to review these staffing changes, which affect condition A.A.3.iii) of the various station operating licences. This committee recommended that the new structure not be approved pending review of all relevant job descriptions, implementation schedules, training program development schedules, etc. - few of which were available for review at the time. Indeed, this documentation is still not available as this report is being written, some six months after AECB site staff received the initial request for approval.

A-III-11 Control Room Staffing

For the operation of the second unit (Unit 1) at Darlington NGS 'A', a temporary concession was granted regarding the number of first operators required. Due to the AECB's concern regarding supervision of Unit 0 during a major transient, the original licence condition for the first operating unit (Unit 2) required Darlington NGS 'A' to assign an extra Authorized Operator to the control room, in addition to those required for the operating units. Because this condition could not be complied with prior to Unit 1 criticality, Darlington NGS 'A' offered an acceptable, albeit temporary alternative; to wit, provide training for the Shift Supervisors (SS) to enable them to ensure correct operator response to the initiation of Unit 0 safety systems in the event of a major transient or abnormal incident.

To this end, a dedicated training program was put together to cover most of the Unit 0 related abnormal incidents. All of the Shift Supervisors who were authorized at the time satisfactorily completed this training at the Darlington NGS simulator. AECB Project and Operator Certification staff observed all of the testing and most of the follow-up sessions. Resolution of this licensing issue in the long term is still required.

A-III-12 Tritium Removal Facility

In early March 1991, AECB staff conducted a health physics appraisal to assess the following: i) the effectiveness of the measures taken by the licensee for contamination control in the TRF/Heavy Water Management Building (HWMB), and ii) the radioactive gaseous effluent monitoring for the TRF/HWMB ventilation stack.

The overall conclusion of the appraisal was that most routine aspects of contamination control in the TRF/HWMB were adequately performed, although a number of weaknesses were observed. Many stem from the fact that the required facilities for effective contamination control, such as change rooms and showers, maintenance shops, decontamination facilities, etc. are still housed in temporary structures. Construction of a permanent TRF Annex to contain these facilities has not yet been approved by Ontario Hydro Management. The performance of the monitoring equipment as demonstrated was found to be satisfactory, with the exception of some concerns about the long sampling line to the monitors.

AECB staff has recommended that the planned TRF Annex should experience no further delay. AECB staff also recommended that a properly designed unloading facility for the transfers of large volumes of tritiated water be part of the planned TRF Annex. AECB staff informed the Board members of these findings. The Board in turn directed AECB staff to ensure that significant progress is made on this issue before relicensing of the TRF is considered in 1992.